

## **ELECTROACTIVE POLYMER (EAP) ACTUATING A DUST WIPER AND MINIATURE ROBOTIC ARM**

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For many years, electroactive polymers (EAP) received relatively little attention due to the small number of available materials and their limited actuation capability. The recent emergence of EAP materials with large displacement response changed the paradigm of these materials and their potential capability. The main attractive characteristic is their operational similarity to biological muscles, particularly their resilience and ability to induce large actuation strains. Unique robotic components and miniature devices are being explored, where EAP serve as actuators to enable new capabilities. In recognition of the need for international cooperation among the developers, users and potential sponsors, an SPIE Conference was organized for the first time on March 1-2, 1999, in Newport Beach, California. The conference was the largest ever on this topic of EAP and it marked an important milestone turning the spotlight onto these emerging materials and their potential. Further, a newsletter called WW-EAP was initiated to bring the worldwide EAP community even closer. ([http://eis.jpl.nasa.gov/ndeaa/nasa-nde/newsltr/WW-EAP\\_Newsletter.PDF](http://eis.jpl.nasa.gov/ndeaa/nasa-nde/newsltr/WW-EAP_Newsletter.PDF))

A challenge was posed to the EAP science and engineering community to develop a robotic hand that is actuated by EAP and able to win against a human in an arm wrestling match (Figure 1). Progress towards this goal will lead to great benefits, particularly in the medical area including effective prosthetics. Decades from now, EAP may be used to replace damaged human muscles, leading to a "bionic human" of the future. My hope is to someday see a handicapped person jogging to the grocery store using this technology.

At JPL, using EAP planetary applications are being explored while improving the understanding, practicality and robustness of these materials. This research and development effort is conducted under a NASA task and the team consists of JPL, NASA-LaRC, VT, Rutgers University, and ESLI having cooperative efforts with Osaka National Research Institute, Japan, and, Kobe University, Japan. This NASA task is called Low Mass Muscle Actuators (LoMMAs). Using a bending EAP type material, a dust wiper is being produced for the NASA/NASDA MUSES-CN mission. The development of the wiper is at advanced stages and if flown it would be the first practical application ever recorded for such large actuation displacement EAP materials. This dust-wiper is being developed for the infrared camera window of the mission's Nanorover (Figure 2). The MUSES-CN is a joint NASA and Japanese space agency mission that is scheduled for launch in January 2002, from Kagoshima, Japan, to explore the surface of a small near-Earth asteroid. The team is testing the use of highly effective ion-exchange membrane metallic composites (IPMC) made of perfluorocarboxylate-gold composite with the two types of cations, tetra-n-butylammonium and lithium. Under a potential difference of less than 3-V, these IPMC materials are capable of bending beyond a complete loop. A unique ~100-mg blade with fiberglass brush was developed by ESLI (San



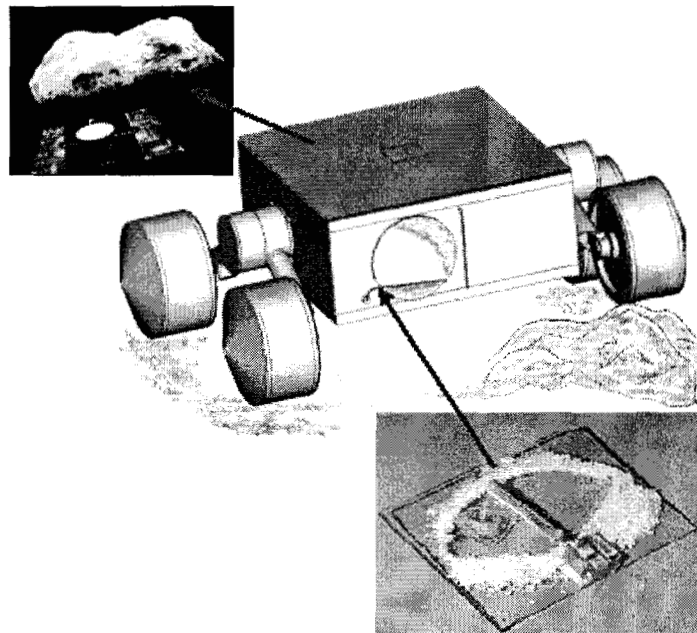
**Figure 1: Grand Challenge for the EAP Community**

Diego, CA) and is subject to a high voltage to repel dust augmenting the brushing mechanism provided by the blade.

Generally, space applications are the most demanding in terms of operating conditions, robustness and durability and the team is jointly addressing the associated challenges. Several issues that are critical to the operation of IPMC are examined, including its response in vacuum and low temperatures, as well as the effect of the material electromechanical characteristics on its actuation capability. The use of highly effective IPMC materials, mechanical modeling, unique components and a protective coating are increasing the probability of success for the EAP actuated dust-wiper. Another application of EAP actuators is the development of a miniature robotic arm with closed-loop control (Figure 3). A longitudinal EAP actuator, following a development at SRI international, is used to lift and drop the arm, whereas a 4-finger gripper is used to grab rocks and other objects. The bending EAP material shown in this figure was provided by UNM under a prior phase of the NASA LoMMAs task.

The practical application of EAP materials is still a great challenge. No effective and robust EAP material is currently available commercially. Further, there is no established database that documents the properties of the existing EAP materials. Even the issue of testing these materials is a challenge and it is currently being addressed under a recently awarded contract from DARPA.

**FIGURE 2:** Schematic view of the EAP dust wiper on the MUSES-CN's Nanorover (right) and a photograph of a prototype EAP dust wiper (left).



**FIGURE 3:** A miniature robotic arm using EAP actuators to provide the lifting/dropping of the arm and manipulate the gripper fingers.

